Modern Computational Accelerator Physics

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What we have learned so far

Integrating ODEs

- Integrating using GSL
  - Lower-order methods work, but require many steps,
  - Higher-order methods can sometimes produce accurate results with (sometimes dramatically) fewer steps.
    - *Not proven: generally true for smooth functions*
  - Higher-order steps are more complicated.
    - Time per step is higher.
  - Optimal speed for finite-order methods
    - Higher orders stop being faster at some point.
    - Optimal order is problem-dependent.
  - Classical methods have limitations with respect to long-time simulations.
    - Error not bounded.
    - Energy increases/decreases monotonically with time.

Integrating ODEs (2)

- Symplectic integration
  - Method we used was only second order.
  - Requires many steps for an accurate solution.
  - Higher orders possible?
    - Yes, see later...
  - Stable over long term.
  - Error stays bounded.
  - Energy nearly constant.
- n.b.: symplectic integration is interesting in other fields, particularly orbital mechanics
- Which methods are best (classical or symplectic) depends on the problem.
  - Long-term simulations require symplecticity.
  - Classical methods might be more accurate/efficient in the short term.

End of Part 1

Next, we turn to topics more specific to accelerator physics.
We will return to symplectic integration, but only after we have built up enough machinery to do it in a realistic accelerator context.